ITER Fast Plant System Controller Prototype Based on PXI Platform

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Presented BY

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Outline

- Project scope and requirements.
- FPSC HW elements.
- FPSC SW elements.
  - Applications running in the controller.
  - Data acquisition. FPSC control using EPICS PVs
  - Streaming/archiving applications
- Conclusions

Project Scope and Requirements: Plant System Controller

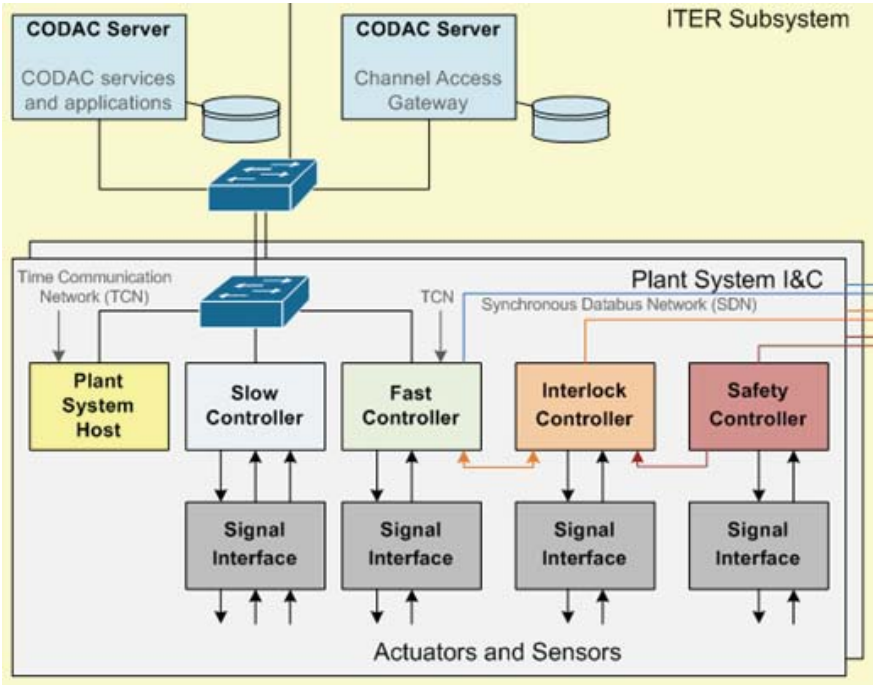
- Plant System Controller (PSC): Plant specific information on
  - Data acquisition
  - Control
  - Monitoring
  - Alarm handling
  - Logging
  - Event handling

- Two types of PSC:
  - Slow PSC
    - Based on industrial automation technology
    - Control loops rates <1 kHz
  - Fast PSC (FPSC)
    - Based on embedded technology
    - Stringent real-time requirements
    - Higher sampling rates

Project Scope and Requirements: FPSC

- Essentials requirements of FPSC:
  - Data acquisition and preprocessing
  - Interfacing with the networks (PON, TCN, SDN, streaming/archiving networks)
  - LINUX OS and EPICS IOC. System setup and operation using process variables.
  - COTS solutions

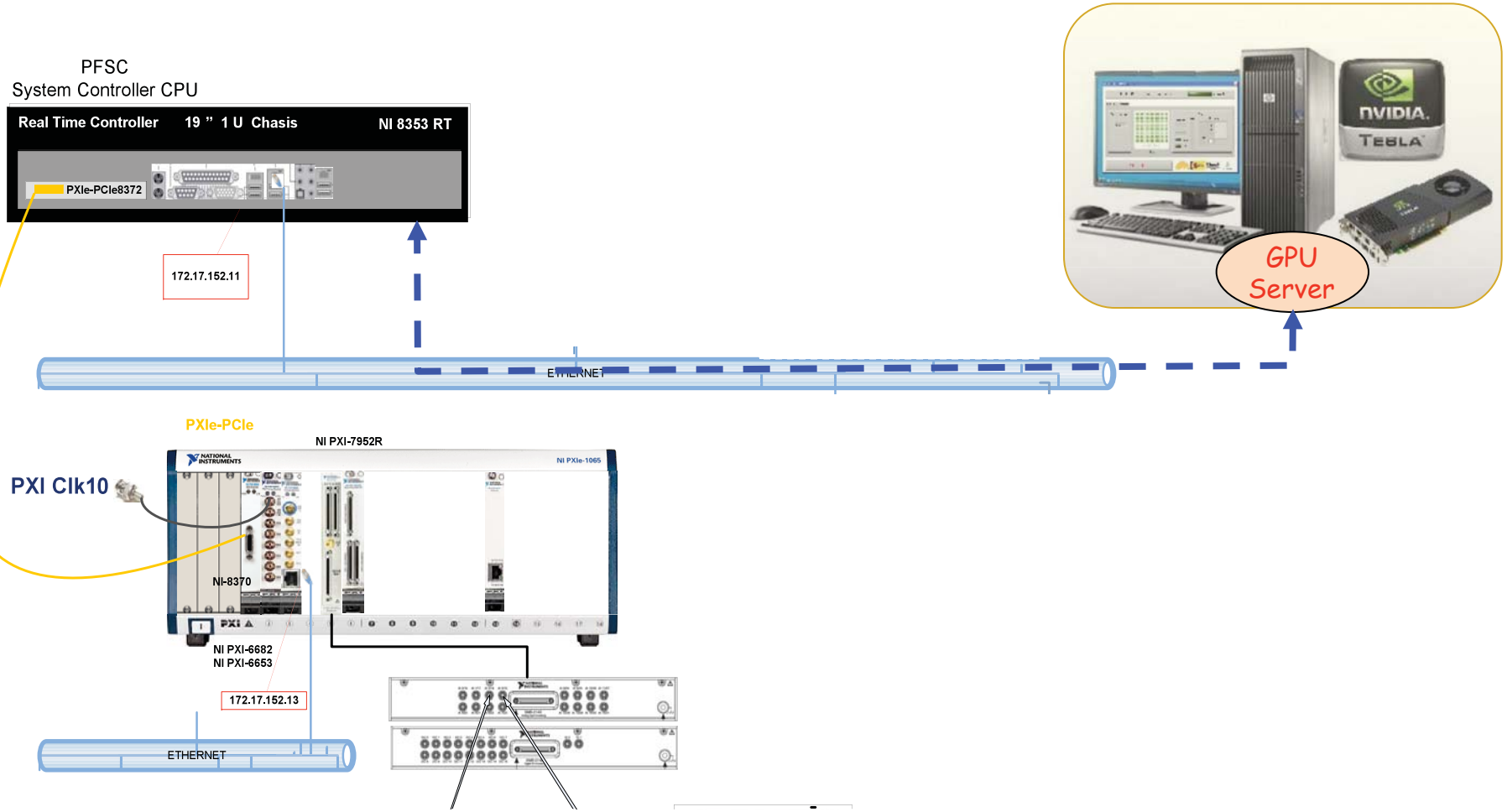
- Developing a prototype FPSC targeting Data Acquisition for ITER IO
  - A two steps approach: Alpha and Beta version.
- Challenges at the start of the project (2010)
  - Drivers (and device support) not available under Linux 64 bits
  - Complicated development to be finished in a limited time



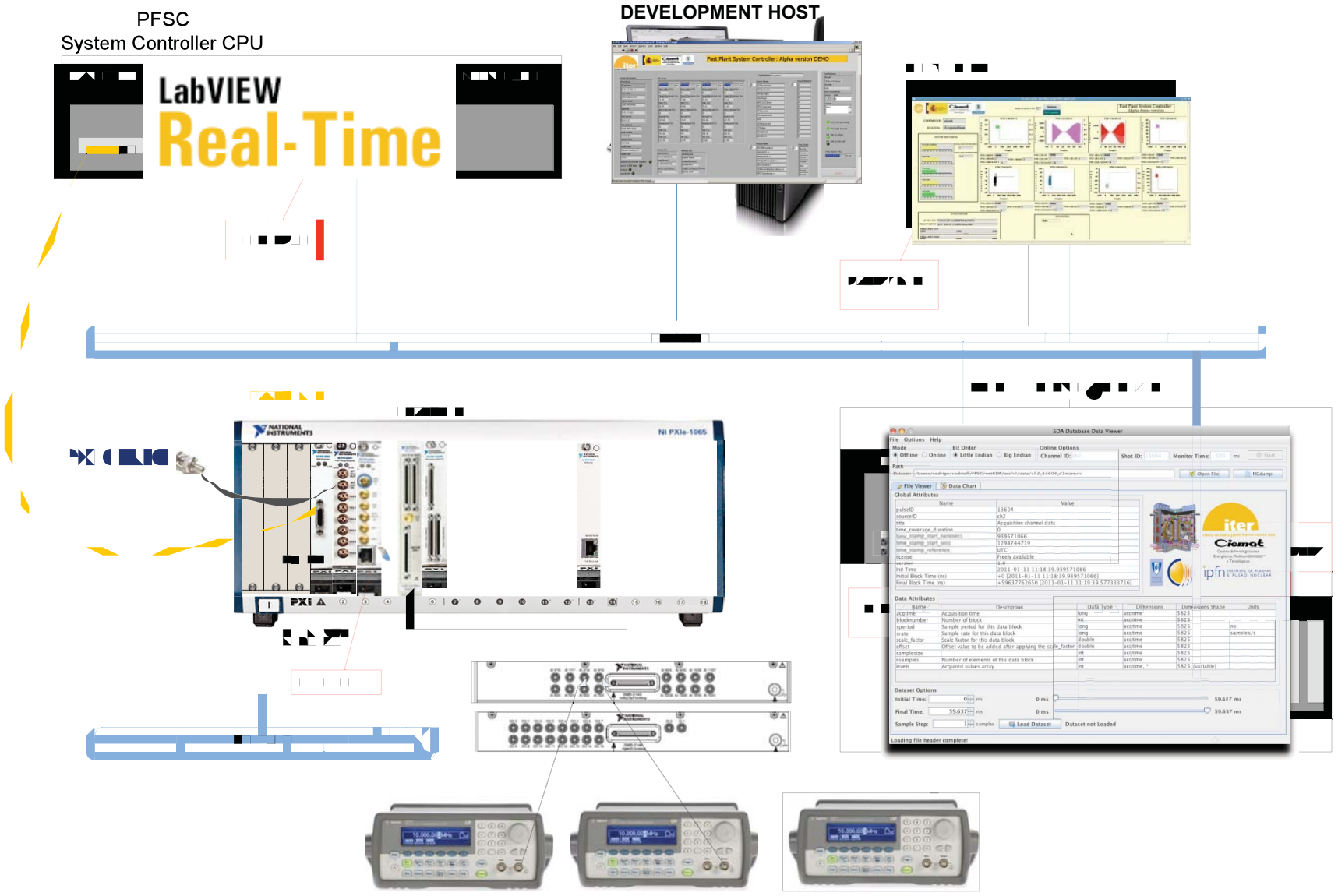
Alpha Version Solution: PXI Form Factor

- PXIe solution using:
  - National Instruments hardware (PXI chassis, timing modules, DAQ using FlexRIO and external controller)
  - LabVIEW RT Module applications running in the controller
  - LabVIEW FPGA for FlexRIO
  - LabVIEW EPICS Channel Access Server for real time targets
- Labview Real Time based
  - For quick prototyping and test system capabilities
  - Gain experience for beta version
- Specific application developed running in external computers for streaming/archiving, data processing with GPUs, and monitoring using ITER CODAC Core System.

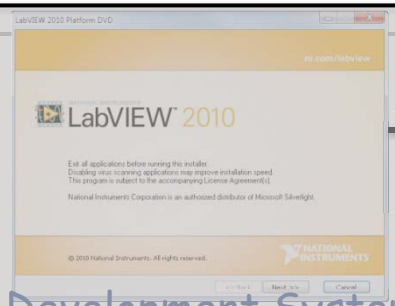
HW Elements: Block Diagram



Development tools



FPSC Software Elements



Development System

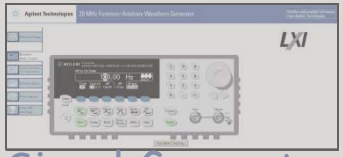
1

EPICS IOC

FPSC Labview RT

EPICS IOC

FPSC GPU System



Signal Generator

EPICS IOC

Archiver Service

3

d1wave and event files

Archiver Service

EPICS IOC

NFS

CODAC State Machine

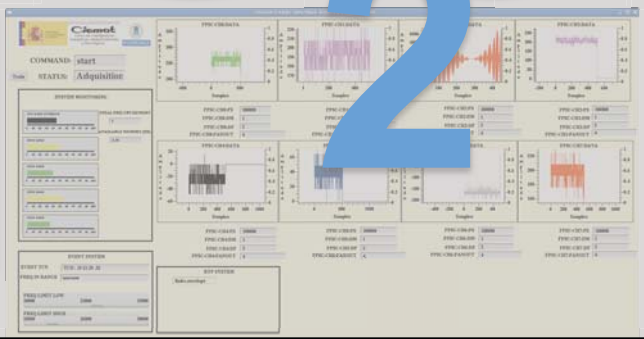
CODAC IOC

iocLog Service

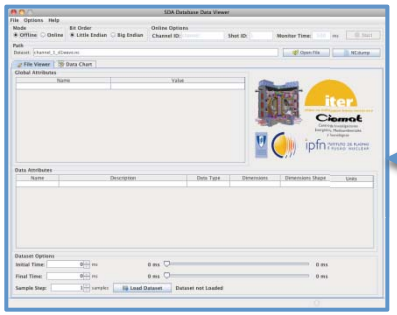
Configuration Management

2

Pulse Control

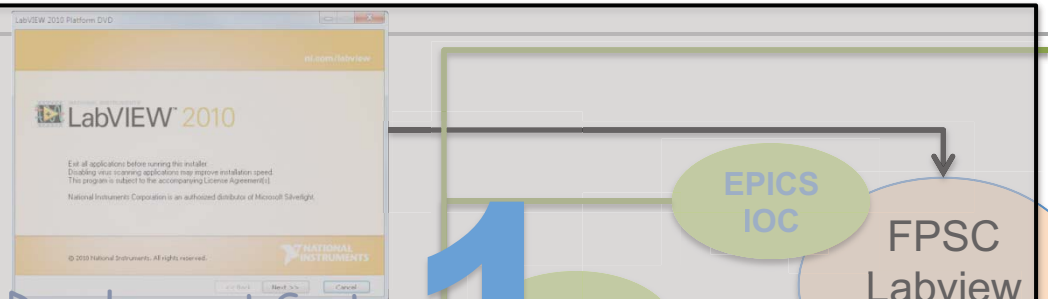


Archiving monitoring



Archive Viewer

FPSC Software Elements



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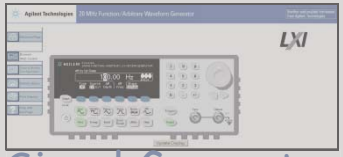

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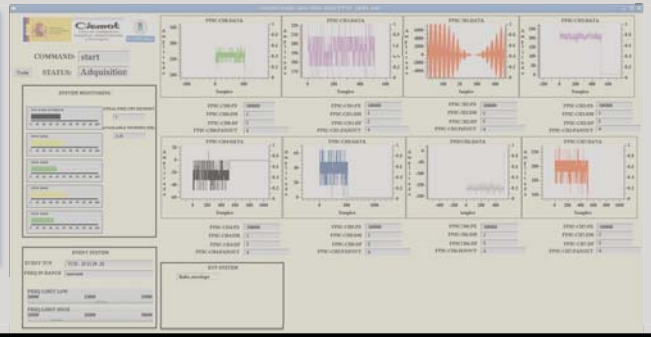

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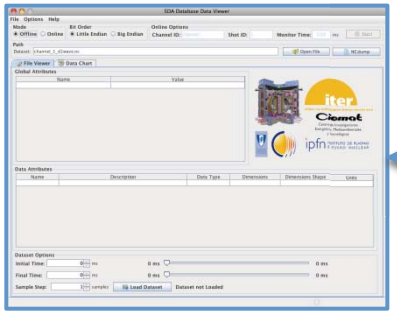

Archive Viewer

FPSC software elements

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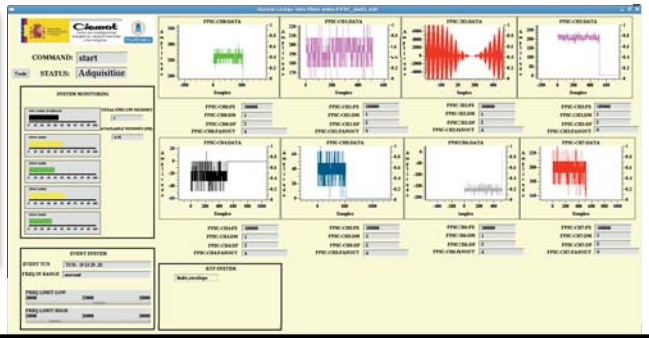

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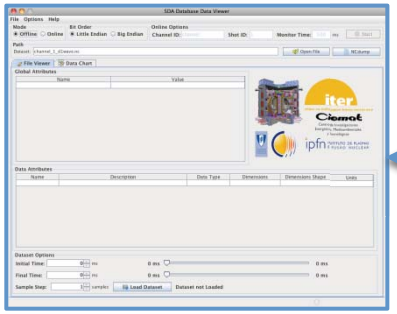
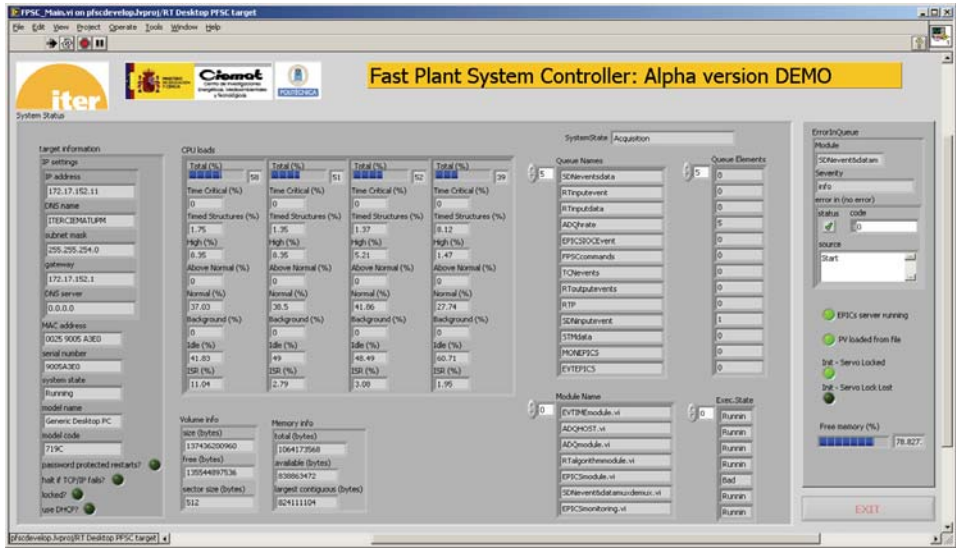
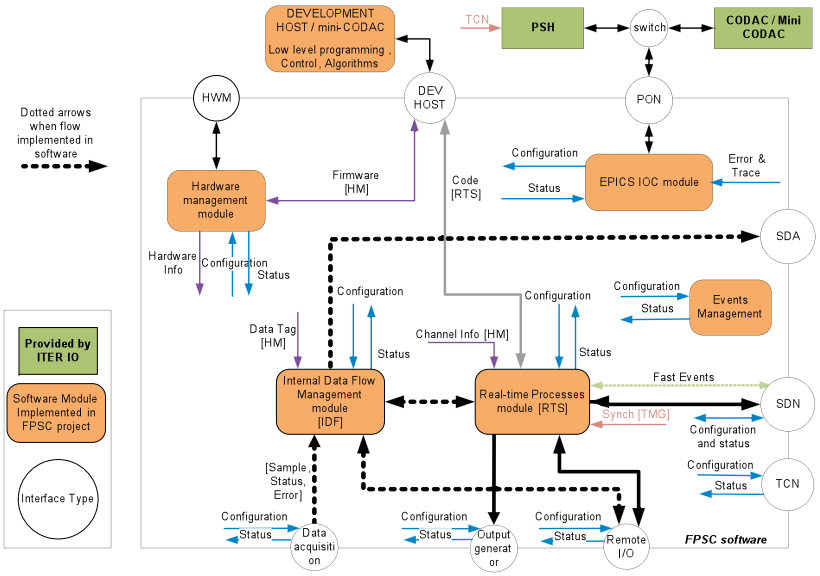


Archive Viewer

FPSC applications running in NI8353 computer

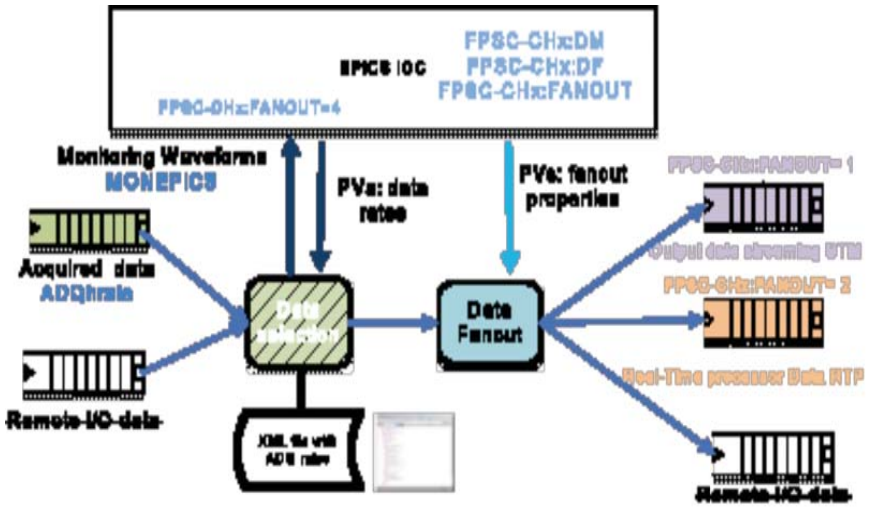
- LabVIEW Modules implemented:
  - CORE: General queues management. Creation, destruction and state machine control.
  - EPICS: Channel access and PVs management.
  - TCN: Management of PXI6653 and PXI6682 for clock generation and event time-stamping.
    - PXI CLK 10MHz is in phase with PXI6682 IEEE1588 clock
  - ACQ: Data acquisition and selection.
  - FPGADAC: Data acquisition application for RIO devices with time-stamping. Also include a signal simulator (inside FPGA) for debugging purposes.
  - EVT: Event management. SDN: Implemented using NI-Time Triggered Variables
  - RTP: Real time processing. Basic algorithms. RTPGPU: GPU management.





Highlights of FPSC software

- ADQ parameters are controlled & changed using PVs (also during the pulse):
  - Sampling rate and block size for FlexRIO device.
  - Decimation factor and modes (samples and blocks) for EPICS monitoring
- FPSC State machine control and status using PVs: start/stop, memory used, CPU load, etc.
- Acquired data can be sent to streaming, monitoring with EPICS, real time processing and GPU using «FANOUT PVs».
- Preprocessing algorithms can be dynamically selected using PVs.



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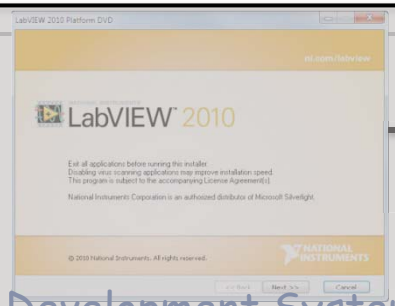

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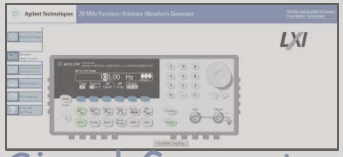

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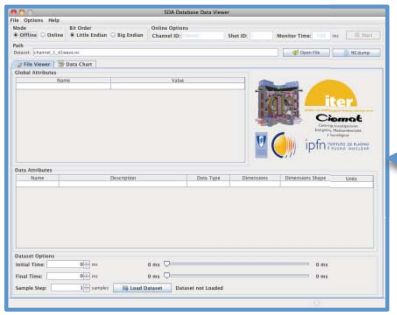
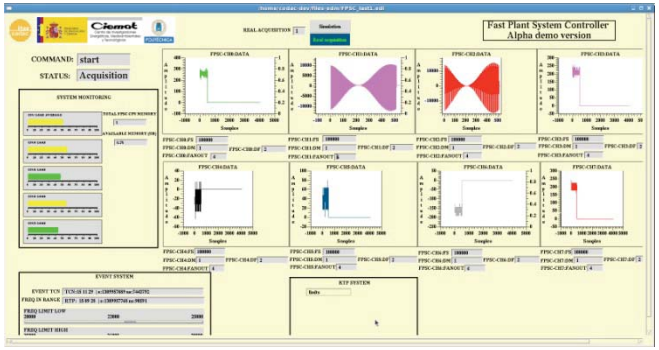
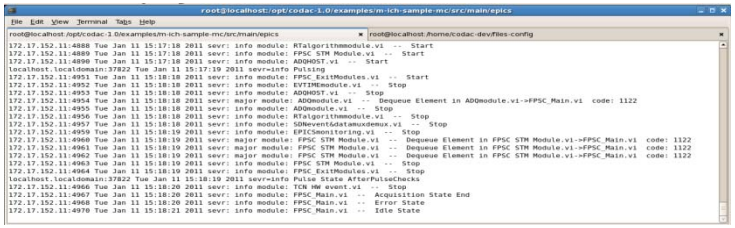
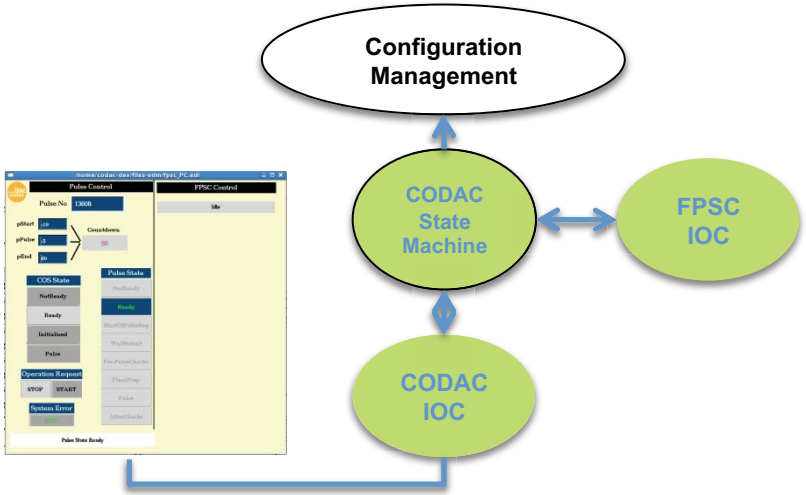


Archive Viewer

GUI using EDM (EPICS), LOG and states machine

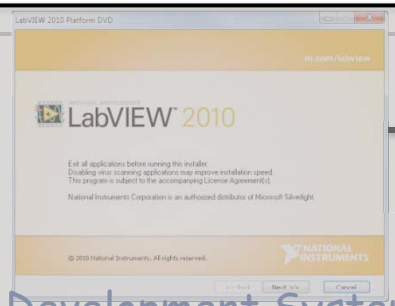






- Manual start/stop of FPSC
- Basic control of PVs during the pulse.
- Implementation of IocLog client in LabVIEW
- IOC with the pulse states machine and configuration management (XML files)

FPSC Software Elements



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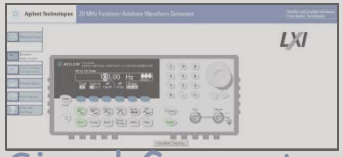

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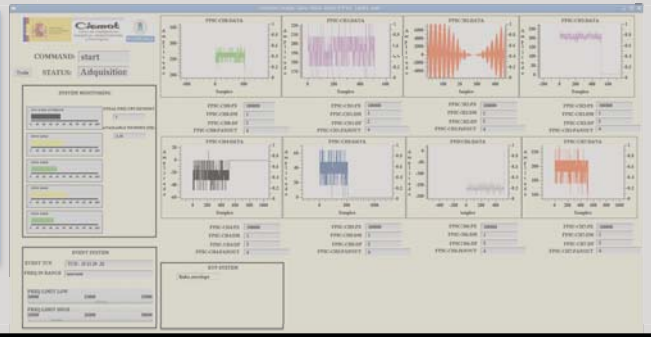

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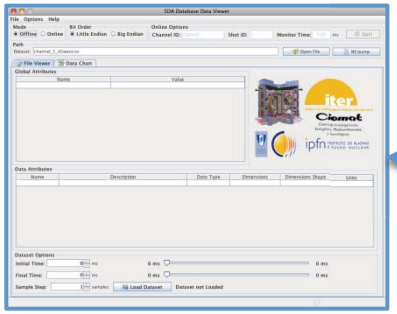

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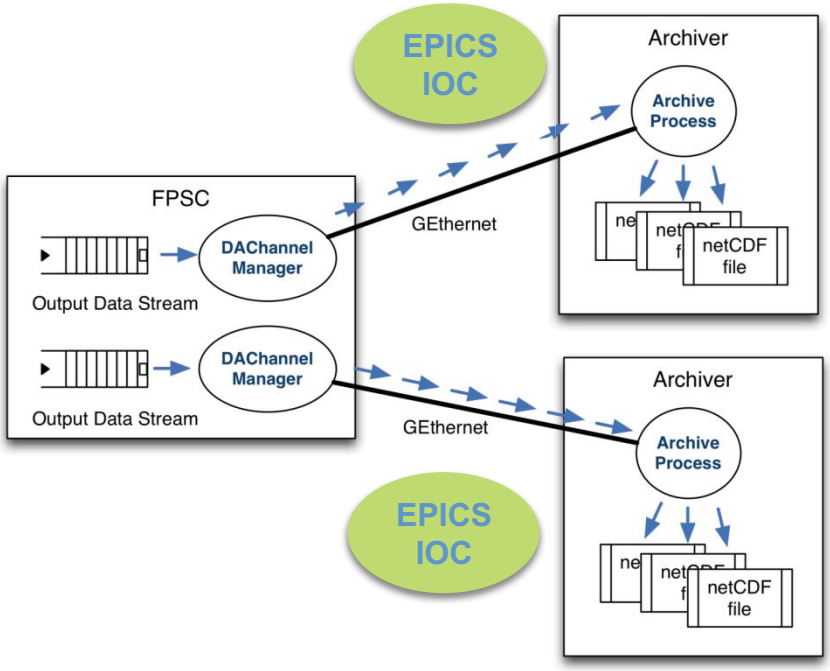
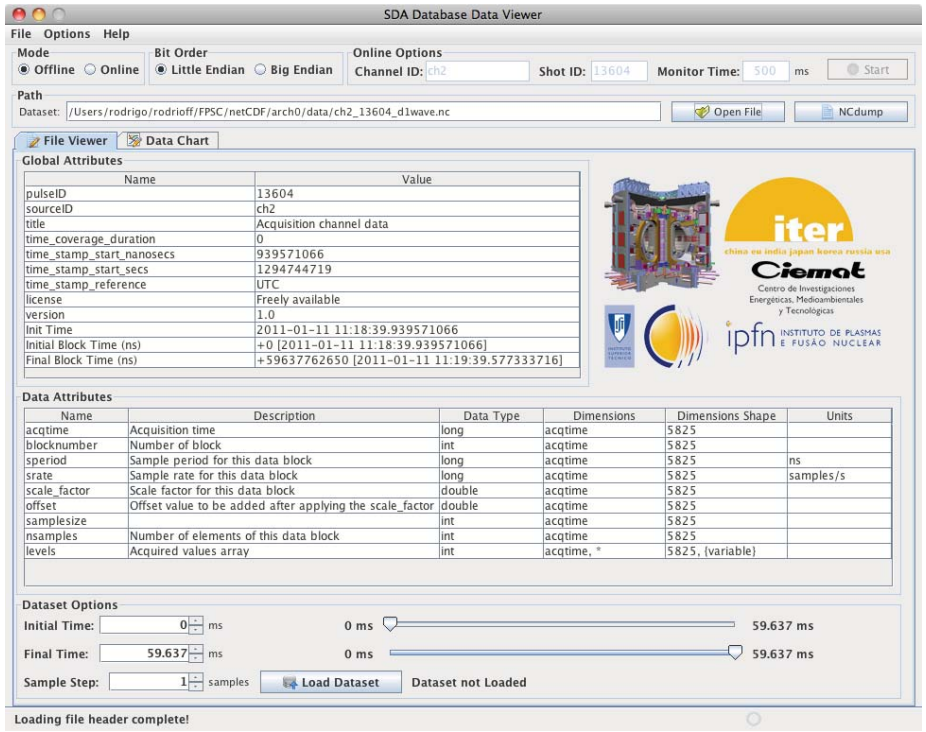


- Data sources can be assigned to data archivers
- netCDF file is the fundamental storage unit
- A file per data source (signal) and pulse
- Two types of data are currently implemented: "d1wave" and "event".
- EPICS IOC currently used for monitoring

Archiving Viewer and monitoring



- "Online" and "Offline" mode
- On remote via NFS (Network File System)
- Time slice positioning
- Self Description data visualization
- Flexible plotter
  - Zooms
  - Export options
- Completely based on EPICS channel access
  - Every archiver implements its own EPICS IOC
- System variables:
  - CPU load
  - Memory Usage
- Archiving system performance
  - Receiving data rate per channel
  - Total received data rate
  - Storing data rate per channel
  - Total saved data rate

Conclusions

- Implementation of a basic FPSC devoted to data acquisition following essential ITER requirements:
  - "Intelligent data acquisition" using FPGA DAQ devices with IEEE-1588 time-stamping.
  - System DAQ parameters controlled by EPICS' PVs (changed dynamically during the PULSE)
  - Streaming capabilities.
  - Preprocessing algorithms using local processor and GPU (controlled with EPICS PVs).
  - Integration with EPICS CODAC system (v1.1).
  - 100kS/s per channel with streaming, time-stamping, EPICS monitoring, and 2 channels preprocessing
- LabVIEW based tools (RT/FPGA) have been a good choice for quick prototyping in a short period of time (3 months).
  - Graphical oriented design simplifies: the definition of complex software models , the debugging of the different applications, and the test of complex hardware setups.

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Thank you for your attention!!

CIEMAT: J. Vega, R. Castro

ITER: N. Utzel, P. Makijarvi.

Technical University of Madrid: M. Ruiz, J.M. López, E. Barrera, G. Arcas, D. Sanz & J. Nieto

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